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Collaborating across institutional and jurisdictional boundaries: enabling the emergence of a national innovation system through public knowledge management

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Abstract
Public institutions involved in research that aims to strengthen the productivity, profitability and adaptiveness of industries face a multiplicity of challenges when managing for the emergence of cost effective solutions to problems. We reflect upon the learnings of a Government sponsored Visiting Fellow's programme that we describe as a knowledge management (KM) intervention within Australia's primary industries Research, Development and Extension (R, D and E) system. Our central concern is to draw upon the learnings of an internet-based initiative in the United States called eXtension to show how 'traditional' D and E activities can be transformed. We argue that organisations and networks involved in such D and E activities need to perceive themselves as belonging to systems that are socio-technical in nature. That is, the development and deployment of cross-jurisdictional and cross-institutional innovations are shaped by both the social interactions between people and the systematic use of technology to support distributed learning. We explain how the elements of an integrated model to support public KM can be developed to create the conditions for enhanced innovation. Our findings have relevance to a wide range of other industry sectors considering contemporary service models involving public and private partnerships.
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> A good sheep is a good sheep regardless of how you get there, but I don't believe in the figure world or picking a ram off a computer. … I'd rather put my trust in looking at the sheep and seeing how it performs, than in some number dreamed up by some scientists on a bit of paper. (Mr. Wal Merriman - Former President, Australian Stud Merino breeders Association, cited in Neale, 2012)

Introduction

Organisations with responsibilities that mediate public and private interests in Australian agriculture face a substantial knowledge challenge. Significantly, a core element of this challenge is how to agree on, identify and maintain 'trusted knowledge', including how knowledge is created, communicated and used to create and deploy innovations, solve identified problems and enable change. We consider this to be a public knowledge management (KM) challenge.

In this paper, a case study of a KM intervention is presented in order to explore some of the public KM challenges that need to be taken into account as the Victorian Department of Environment and Primary Industries (DEPI) works to strengthen its services, including those related to: agricultural productivity and profitability; the sustainable management of water resources, public land, forests and ecosystems; and climate change and natural disasters such as bushfires. DEPI is the name of the Department created in April 2013 through the merger of the Department of Primary Industries (DPI) and the Department of Sustainability and the Environment (DSE). As this occurred during the case study in question, the Department is referred to as DPI or DEPI where appropriate.

There are three different aspects to this case study. First, it is based on the findings of DPI Visiting Fellow's programme. The objective of the programme is 'to access new knowledge, skills and technologies, foster new relationships and create new strategic networks, alliances and collaborations with overseas scientists and experts' (Department of Primary Industries (DPI), 2012). Through this programme, the Farm Services Victoria Division of DPI hosted two Visiting Fellows from the US eXtension initiative – National Director, Mr. Dan Cotton (hereafter 'Cotton') and Associate Director, Dr. Craig Wood (hereafter 'Wood') in the periods 10–14 September 2012 and 18–27 March 2013, respectively. The US eXtension initiative was established in 2004 as a small-scale internet business designed to support the transformation of work practices of the Cooperative Extension System (CES) of the United States Department of Agriculture (USDA). It has become a national internet-based network providing access to reliable, science-based information from land-grant universities and partners nationwide. It aims to serve the needs of new and traditional customers, partners and stakeholders by providing the most relevant information and educational programmes generated by CES nationwide (Cotton, 2012).

From the outset, the eXtension initiative was conceived to be transformational (eXtension, 2013a). It was developed from scratch as a virtual extension service (e-CES) in classic, new market entrant, start-up mode 'to overcome the traditional barriers to which incumbents appear blind or by which they are constrained' (King & Boehlje, 2000). Central to the initiative is the idea of cross-institutional and cross-jurisdictional collaborations – working together across existing boundaries to broker national priorities tailored to local needs and local needs addressed at all levels (Cotton, 2012). DPI was particularly keen to learn as much as possible about eXtension, how it operates and what might have been the major lessons learned since its establishment in 2004.

The second aspect of this case study is that the visits by Cotton and Wood have been set within the context of Australia's primary industries Research, Development and Extension (R, D and E) framework developed through the Primary Industries Standing Committee (PISC) umbrella structure. This framework recognises that basic strategic R can be undertaken at a national level, with regional adaptive D for this research, combined with local E. The objectives of this approach are to improve the uptake of innovation within industry (DAFF, 2009) and to harness local, regional, state and national resources in a coordinated way to minimise duplication of effort and to foster what we regard might be a primary industries R, D and E innovation system.

The third aspect of the case study is that a serious attempt has been undertaken to analyse what might need to be taken into account if aspects of the US eXtension model are to be adapted to an Australian context. This analysis was undertaken through a business consultancy that involved Mr. Michael Jones and Associate Professor Gavan McCarthy (joint authors of this paper) from the eScholarship Research Centre (eSRC) at the University of Melbourne. Their assignment was to shadow Wood throughout his visit, to provide an accurate summary of key themes discussed and synthesise aspects of key events and themes to provide expert advice to DPI based on preliminary analysis. The purpose of this was to identify what might need to be required going forward to further develop an eXtension type business model in order to suit Australia's specific institutional and policy requirements. Overall, the objective has been to create the conditions within which Australia's primary industries R, D and E framework could emerge as a driver and enabler of local, regional, state and national innovation.

Using the DPI Visiting Fellow's programme as the primary lens for describing this case study as a KM intervention is consistent with the KM literature. For example, Aujirapongpan *et al* (2010) undertook a literature review related to capabilities required for KM and concluded that KM consists of four core processes – knowledge acquisition, knowledge creation, knowledge storage and knowledge application. The DPI Visiting Fellow's programme is consistent with two of the four core KM processes – in that the programme has allowed the pursuit of knowledge acquisition objectives, but explicitly with the intention of applying this knowledge (knowledge application).

Developing this paper as a case study of a KM intervention has added benefit because it provides a framework within which the implications of acquiring and applying new knowledge can be iteratively analysed. This also is consistent with the literature in that core KM processes should not be treated as discrete and separate, but cyclic and interactive in line with the SECI[1] model (Nonaka & Takeuchi, 1995; Nonaka *et al*, 2006), as well as complex systems perspectives of KM including single and double loop learning (Blackman *et al*, 2004), the knowledge life cycle (Firestone & McElroy, 2003a); Observation, Orientation, Decision and Action (Boyd, 1976–1996) and a four tiered knowledge hierarchy (Vines *et al*, 2011). For example, knowledge can be acquired both from internal or

[1]SECI refers to Socialisation, Externalisation, Combination and Internalisation.

external sources to an organisation (knowledge acquisition) and then applied to test its relevance in an unfamiliar context (knowledge application). Knowledge is created when a trial or pilot is enacted within a specific context and findings are written up (knowledge creation). The knowledge artefacts including documents, videos, databases and the like are iteratively created throughout these knowledge cycling activities so these can be stored (knowledge storage).

Description of the system intervention

Target audience

In establishing the agendas for the visits by Cotton and Wood some clearly defined objectives were set. For example, Cotton's visit provided an opportunity to fully brief DPI staff and representatives from Australia's agricultural industries about the nature of the eXtension initiative, its objectives and how it operates. Following on from the success of this visit, Wood's visit aimed to provide opportunities to discuss how an eXtension type initiative might be specifically applied to the grains, beef, horticultural and dairy industries within an Australian context. A wide range of events involved representatives from several different DPI divisions, Research and Development Corporations (RDCs), private service providers, farmers, industry bodies and other research organisations such as cooperative research centres. Two 1-day national forums were held. The first involved the chief executive officers of Australia's RDCs and senior leaders from relevant state government agencies to explore the level of interest in further investigating the applicability of the eXtension business model to Australia. The other was devoted solely to investigating the possibility of establishing two pilot learning networks in Australia's Grains industry in the specialist areas of soil nutrition and crop pathology. The term 'users' referenced hereafter encompasses experts, researchers, employees of organisations (commercial and non-commercial), farmers and producers, and includes people who are not 'traditional' extension clients. Broadly, the term refers to citizens or the population at large. When referring specifically to farmers, producers and related consumers (whether traditional extension clients or not) we use the term 'end users'.

Key themes

During their visits, Cotton (2012) and Wood (2013) explored a number of key concepts and topics that form the basis of the eXtension Initiative in the United States. Central to the initiative are notions of cross-institutional and cross-jurisdictional collaborations – working together across existing boundaries to help solve common problems and meet the shared needs of users and end users. This approach is supported by three key features of eXtension. Conceptually, eXtension is based on the idea that people are looking to solve real challenges and find reliable answers in real time, without any vested interest in whether those answers come from government agencies, universities, industry groups or others – provided the information is understandable, reliable and applicable to their situation – and that people working collectively provide greater benefit to all stakeholders than people working separately. Organisationally, eXtension is governed by the not-for-profit eXtension Foundation, which sits outside the specific organisations making up the network and has negotiated agreements with all those involved regarding intellectual property and liability. Technologically, eXtension has been set up as an online collaborative environment that operates separately from internal organisational systems and information technology.

The key groups supported by this framework are communities of interest (groups of people with common interests, issues or concerns about life events – hereafter referred to as CoIs), communities of practice (groups of people with related expertise – hereafter referred to as CoPs), and learning networks (where these two communities engage and interact to share information and expertise for the mutual benefit of both – hereafter referred to as LNs). Each community works collectively to develop shared values, a 'code of conduct', and a collaborative approach to knowledge creation and the resolution of issues. When most effective, these groups are not specifically created or imposed based on existing organisational structures or strategies. They form and emerge based on interaction and feedback between the people involved.

Technology is used to support new ways of engaging with users. Working in the 'cloud' means communities and networks no longer need to be co-located to work together. Content can be drafted, reviewed and published in a shared environment, and can continue to evolve in response to emerging issues and new ideas. Peer review by the relevant community ensures this content is authoritative and reliable. Moreover, well-structured and maintained systems ensure all content is discoverable, publicly accessible and preservable over time.

The intention of online collaborations via the eXtension framework is not to replace existing commitments to extension practice. Instead, working online across existing boundaries means those involved have an opportunity to transform the way they work by supporting collaboration across institutional and jurisdictional boundaries. This leads to opportunities for shared access to expertise and authoritative content. 'End users' also have enhanced access to reliable material and expertise in real time, and can utilise existing content or ask questions directly using an online 'Ask an Expert' module. Therefore, online collaborative eXtension helps to reach new audiences, better supports existing end users, improves access to information and expertise across the sector, and makes more effective use of existing resources.

Feedback

The polling of participants throughout Cotton and Wood's visits indicated a high level of interest in and

engagement with the eXtension initiative. For example, 88% of participants who completed survey forms indicated that their expectations had been met (or exceeded), 87% indicated they learned something new and 76% indicated they planned to use what they had learned in their work going forward. However, equally, there was unanimous feedback noting that the land grant university institutional context for eXtension in the United States is fundamentally different to the Australian context. Discussions highlighted that R, D and E activities in Australia are funded and carried out by a complex web of research providers and investors. Participants emphasised that the purpose of the primary industries R, D and E framework is to support collaboration, and improve information flows, knowledge and capability sharing, specifically as these relate to research outputs. For example, the KM guidelines that underpin this framework include the requirement that metadata about resources be harvested by the National Library of Australia. Further, background research related to this visit, indicates that the R, D and E expertise required to effectively support an eXtension type initiative in Australia is currently distributed across multiple state and federal agencies encompassed by three key funding nodes that make up the $A1.6 billion spent on rural related R, D and E activities in Australia – the Australian Commonwealth Government – comprising 48%; state and territory governments – comprising 28%; and private industry – comprising 24% (Australian Productivity Commission, 2011). It was noted many times that Australian RDCs play a significant role in terms of brokering cross-jurisdictional and cross-institutional agreements. Recent announcements also made by the NSW and Victorian State Governments referenced during discussions indicate that nationally orientated R, D and E services will need to become more integrated with state and regionally based environmental and natural resource management activities, creating new expanded models of land services (NSW Department of Primary Industries, 2012).

Exploring the evolution of the eXtension initiative through a theoretical lens

One of the core principles underpinning the focus of the eXtension initiative is the organisational commitment to placing the audience at the centre of everything that it does. At its most fundamental level, this involves listening into the questions, issues or impact of life events raised by individuals (Cotton, 2012). These users develop their own particular knowledge frameworks to make decisions. For example, Former President of the Australian Stud Merino Breeders Association Mr. Mal Merriman's personal decision-making principles (his quote of 11 August 2012 opens this paper) could be representative of any end user of an online extension initiative within Australia. According to Merriman, putting his trust in 'looking at the sheep and seeing how it performs' will lead to better results or greater value, than the use of objective scientific research using the 'newest generic breeding value assessment tool' (Neale, 2012).

Personal and explicit knowledge

Merriman's quote highlights there are many different types of knowledge that must first be understood in some detail if we are to appreciate the way the eXtension initiative is structured. We first focus on differences between personal and explicit knowledge. Personal knowledge includes dispositional or subjective knowledge (Polanyi, 1958, 1966; Popper, 1972; Vines *et al*, 2011) and refers to the knowledge embodied in people's natural talent, habit and skill. It also refers to their unconscious propensity to act in certain ways. Such knowledge is subjective and resides in people's minds and may be tacit or implicit in nature. Tacit, in the sense that it cannot be made explicit; implicit, in the sense that it can be made explicit, but it has not yet been (Nickols, 2000; Vines *et al*, 2011). Merriman's ability to look at a sheep and judge its performance is enabled by his personal knowledge – tacit and implicit – developed through years of experience.

Explicit knowledge on the other hand refers to knowledge that is codified in an objectively persistent format (Vines *et al*, 2011). To fully understand the nature of explicit knowledge, below we have drawn upon theories of personal KM, records management and archival practice, and hierarchically complex systems to develop a conceptual framework – as outlined in Figure 1. In developing this framework, our central concerns are twofold. First, we want to use this framework as a basis for designing and developing online collaborative environments to support and extend the work of 'traditional' development and

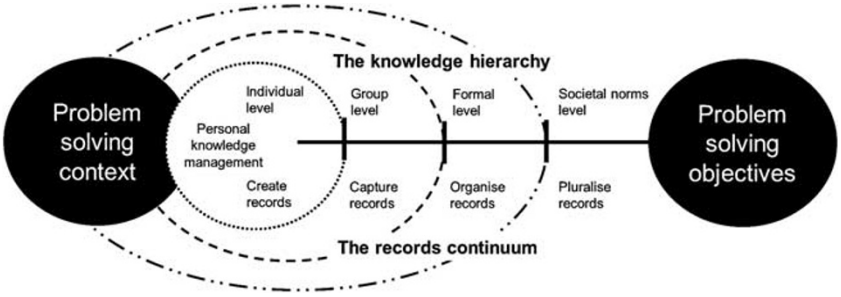

Figure 1 The elements of an integrated model to support public KM.

extension practice, including what might need to be considered if the eXtension model were to be adopted in Australia. Second, by drawing upon five conceptual elements into an integrated model we aim to support what we call 'public KM'.

Elements of a conceptual framework to support public KM

The first element of our conceptual framework is the idea of a 'problem solving context'. We use this term to take into account the perspective that solving problems with knowledge involves both understanding the context of the problem, the context of the knowledge and the relationship of these to the individual actors themselves. We choose this term carefully in order to reflect the same sense as Yakhlef (2008) in his critique of understandings of early conceptual frameworks of CoPs by Lave & Wenger (1991). In this critique, Yakhlef joins Pepperell (1995), Hayles (1999) to describe a new post-human learning context, whereby 'the individual is not the only source or locus of knowledge. Knowing and learning are the outcome of interactions among individuals, artefacts and the structures in the environment; they are uncontrollable and unpredictable'. Yakhlef draws on Latour (1993) to claim that 'subjectivity is not located in consciousness but emergent from networks that are "materially real, socially regulated, and discursively constructed" '. Thus, in using the term problem solving context, we argue that organisations and networks need to be understood as sociotechnical in nature. That is, the factors that influence action-orientated decisions (Smith *et al* 2006) relevant to specific contexts are shaped by the social interactions of people as they go about their work, learn from each other and solve problems collaboratively; and the innovative use of technology to support engagement with audiences, learning, and access to experience and information created in other problem solving contexts (Vines, 2013).

The second element of our framework is the idea of personal KM. Here we focus on individual people as part of a framework for public KM. Jarche (2013) describes personal KM as 'a continuous process of seeking, sensing, and sharing … Seeking is finding things out and keeping up to date … Sensing is how we personalize information and use it … Sharing includes exchanging resources, ideas, and experiences with our networks as well as collaborating with our colleagues'.

For eXtension, the focus on personal KM is of fundamental importance. For example, a CoI emerges when a wide range of consumers come together because of shared interests in solving common problems – each within their own contexts. Part of the evolution of a CoI involves what Vines *et al* (2011) has described as a 'shared context'. This develops via the emergence of a common language to discuss these problems and to pluralise these understandings in some public way. We contend that all of these dynamics fall within the scope of Jarche's concept of personal KM outlined above.

Since its launch, eXtension has developed and deployed technology to support personal KM. However, in doing this, the focus is not just on the individual as the key lens for decision making. It locates the objectives of personal KM within a wider and interdependent network of agents. For example, experts and industry professionals rely on feedback from users to help guide content creation; content creators rely on other users for peer review; all members of the network rely on the technology base and shared agreements regarding content and liability; the eXtension governance is dependent on ongoing support from land-grant universities and the federal government; users rely on the network as a whole for advice and assistance and so on. To this extent, eXtension needs to be understood as a sociotechnical organisation in the way that Harvey (1968) describes the phenomena of people using their machines to mediate internal and external organisational processes.

The third element of our framework is the records continuum developed in Australia (McKemmish *et al*, 2009). This continuum includes four dimensions, the first of which commences at the point in which explicit knowledge artefacts are created and can become a record of evidence of actions taken. The first dimension can also be referred to as 'pre-communication' or 'pre-dissemination' (Upward, 1996). In the agricultural sector, this dimension could refer to the use of evidence in the form of records created, accessed and used by farmers as a basis for making more informed decisions.

To fully understand the implications of 'using evidence as a basis for decision making', we think the addition of a fourth element of our conceptual framework is required. We call this fourth element a 'knowledge hierarchy' – as developed by Vines *et al* (2011). The term 'knowledge hierarchy' is used because knowledge emerges within the context of hierarchically complex systems. Such systems are those where individual parts interact to form a designated system at one 'level of focus' which upon closer inspection can be seen to be composed of several (or many) interacting components at a more detailed, 'lower', level of focus (Simon, 1962, 1973). Vines *et al* (2011) propose that in research intensive networks knowledge emerges in a hierarchically complex system comprised of at least four interacting levels of focus – that is, at the individual, group, organisational and societal levels. Inclusion of this knowledge hierarchy takes into account that evidence of 'what works in solving problems' emerges as a knowledge creation process and this involves the social processes of critiquing, reviewing and testing of knowledge. This is referred to as knowledge cycling, and involves a knowledge creation process that is not explicitly part of the four dimensions of the records continuum.

A description of the dimensions of the records continuum (McKemmish *et al*, 2009) and the linkages to the different levels of a knowledge hierarchy (Vines *et al*, 2011) is provided as follows.

Dimension 1: Documents and content are created as trace. This first dimension encompasses the actors

who carry out the act (decisions, communications, acts), the acts themselves, the creation of content and documents that records the acts and the evidential trace to these acts (McKemmish *et al*, 2009). In the knowledge hierarchy, this equates to the *individual level* where actions are taken and encompass the core concepts associated with personal KM.

Dimension 2: Records-as-evidence are captured. This encompasses the personal and corporate record-keeping systems that capture records in ways that support their capacity to act as evidence of the social and business activities of the units responsible for the activities (McKemmish *et al*, 2009). In the knowledge hierarchy, this equates to the records created and authorised at a *group level*. An example of this dimension and level of hierarchy is the eXtension 'Create' module discussed later in this paper. This is a collaborative workspace used for developing, reviewing and publishing content. All material developed within Create is publicly accessible; however, the site is not indexed by search engines so is not discoverable without provision of a link to a specific page www.extension.org website.

Dimension 3: Records-as-corporate memory are organised. This encompasses the coordination of record keeping processes. It is concerned with the manner in which a corporate body, organisation or individual defines the record keeping regime and in so doing constitutes the archive as memory of its business or social functions (McKemmish *et al*, 2009). In the knowledge hierarchy, different levels of *formal knowledge* emerge over time in the form of records that have been critiqued and approved within an organisation or via external peer review. eXtension ensures there is a level of authority ascribed to this content by requiring that relevant CoPs review each piece of content before that content is formally published. After the review process (and any required revisions) is complete, content is copy edited and published to the public eXtension.org learning environment. If content is out of date or no longer relevant it can be marked as inactive.

Dimension 4: Records-as-collective memory are pluralised. This dimension concerns the manner in which the records are brought into an encompassing framework in order to provide a collective, social, historical and cultural memory of the institutionalised social purposes and roles of individuals and corporate bodies (McKemmish *et al*, 2009). At the *societal norms* level the records of individuals and corporate bodies exist within the context of a range of cultural, legal and regulatory norms. In the case of Australia's primary industries R, D and E framework such norms are established through the publishing of industry sector and cross sector strategies that form an integral part of the framework. A key message advocated in this paper, is that more effort needs to be made to create and publish identifiers in dimension four of the records continuum, so that relationships can be created between sector priorities for R, D and E investments (i.e., sector and cross sector strategies) with records to providing evidence of actions taken, including the evolutionary impact of interventions as these emerge through time.

The fifth element of our framework relates closely to dimension 4 of the continuum and involves the articulation of what we call 'problem solving objectives'.

In the United States, eXtension now plays a role in the fulfilment of the national policy objectives of the US Federal Government through the USDA and its National Institute of Food and Agriculture – NIFA (Wood, 2013). NIFA positively encourages applicants to provide evidence of how they will adopt eXtension systems and processes as part of their grant applications. In Australia, national problem solving objectives are published within individual R, D and E sector and cross sector strategies. For example, the national grains R, D and E strategy document provides 'a framework to encourage greater involvement in priority setting, continuity of investment and improvement in the efficacy and efficiency of R, D and E' (PISC Research, Development and Extension Subcommittee, 2011).

In the cases of both the US and Australia these problem solving objectives emerge as part of the dynamics of a much larger super-system, as compared to the extension related activities that emerge at the local farmer or regional levels. In hierarchically complex systems, the dynamics of these larger super-systems are much slower than lower level systems – thus establishing boundary conditions (Salthe 1985, 1993; Simon, 1973, 2002). Constraints applying downward control may be negative (inhibitory) or positive (facilitative). The dynamic structure of a focal system (the specific states, interactions and trajectories of the components comprising the system) at a point in time establishes conditions that provide a downward control over the dynamic possibilities available to the subsystems comprising the focal system (Pattee, 1973, 2000). The structures providing that control can be considered to embody 'control information' (Corning, 2001; Pattee, 2000). Thus, in practical terms, the content of national R, D and E sector and cross sector strategies act as boundary objects that play a role in constraining the dynamic possibilities of lower level systems. In principle, the objective is to ensure resource allocations are maximised, that resources are allocated to appropriate priorities and that cross cutting innovation opportunities are exploited so that public value impacts can be monitored and maximised. Taking the Grains Industry National Research, Development and Extension Strategy as an example, the current strategy document highlights the need to integrate effectively with other agricultural R, D and E sectoral and cross-sectoral strategies; and highlights the need for 'common definitions and

common impact evaluation assessments' (PISC – Research, Development and Extension sub-committee, 2011).

Implications for the practice of public KM

Complexity theory and public KM

We contend this conceptual framework allows us to better understand the dynamics of public KM and what will be required to enable the emergence of a more effective national innovation system within Australia's primary industries R, D and E framework. We hypothesise that public KM involves working with the dynamics of two distinctly different but overlapping knowledge spaces as outlined in Figure 2. We refer to these as a 'personal knowledge space' and a 'public knowledge space' and a 'boundary space' where there is overlap. This hypothesis correlates with complexity theory and the use of such theory to explain the emergent patterns of CoPs conceived as complex adaptive systems. For example, Borzillo & Kaminska-Labbé (2011) undertook an analysis of five different CoPs and hypothesised that knowledge creation in CoPs results from the co-existence and co-evolution of both top-down and bottom-up processes. These co-evolutionary processes involved the combination and recombination of four complexity constructs, which they called 'adaptive tension', 'enabling leadership', 'enhanced cooperation' and 'boundary spanning'. Knowledge creation results from 'CoPs oscillating between guided and self-directed modes'. To discuss these matters in more depth, we begin by focusing on the dynamics of a personal knowledge space.

Personal KM in a public sphere

The dynamics of a personal knowledge space involves a primary focus on personal KM, the actions taken by and behaviours that emerge when people seek solutions to problems. Drawing upon the experiences of eXtension, it would seem at face value that eXtension is enabling a traditional hierarchical model of knowledge dissemination, with one group (the CoP) taking up a position of authority to pass information 'down' to a receiving group (the CoI). However, as eXtension CoIs and CoIs have evolved, Borzillo & Kaminska-Labbé's (2011) notion of 'adaptive tension' appears to have been at work, to the extent that in recent years eXtension has been aiming to support the evolution of their CoIs and CoPs into LNs. LNs are conceived as more organic, non-hierarchical collaborative groups of related people, with two-way information flows drawing upon people's personal knowledge (whether they be 'experts', researchers, industry professionals or users, producers and consumers). The result is 'enhanced cooperation' (Borzillo & Kaminska-Labbé, 2011) with users drawing upon users' personal knowledge as much as delivering information to them. By implication, moving to non-hierarchical LNs requires a re-evaluation of traditional notions of authority. The idea that a person in a certain field is necessarily more qualified to give advice or create content based on their employment status or organisational affiliation no longer applies. However, in retaining the idea of 'experts' and allowing LNs to evolve over time, eXtension has ensured this change has not resulted in a diminution of the value of knowledge with firm foundations in experience and education. Instead, the concept of a 'learning network' is based on decentralising authority. That is to say, the authority of a learning network evolves as part of the distributed network itself, rather than being considered external to the interaction between people.

Further, when CoPs and LNs form, the way in which each community will work is established from within the community itself. For example, on start-up specific attention is paid to 'enabling leadership' (Borzillo & Kaminska-Labbé, 2011), whereby founding members of the community come together physically or virtually to reach a collective agreement on the roles of leaders, rotating leadership roles, codes of conduct, commitments to how the group will work and shared values.

Iaquinto *et al* (2011) suggests that this enabling leadership could perhaps even be subject of a CoP in its own right – in order to more systematically span the boundary between CoP and organisational learning. This is in line with the 'boundary spanning' function described by Borzillo & Kaminska-Labbé (2011) – for example, ensuring there is license to operate across the boundaries between private and organisational realms through adoption of appropriate policies. For a community to become fully functional, the authority of content is also negotiated by a community process. For example, if there are contested ideas about the best approach to a problem facing the

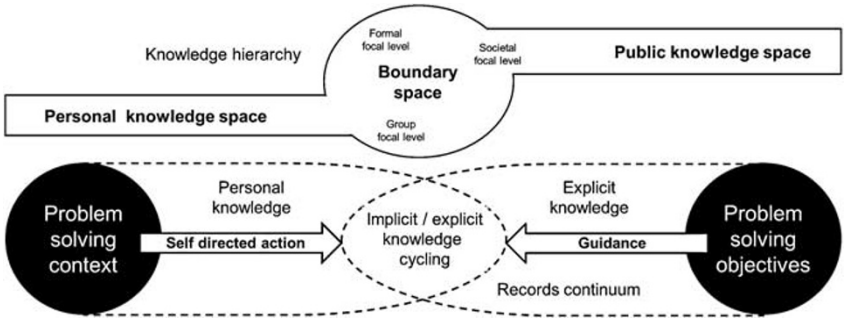

Figure 2 The dynamics of public KM: a complex adaptive systems perspective.

relevant community of interest, the result is not predetermined or confirmed by asserting a dominant view on the community. Two or more pieces of content that outline different options available can be submitted and the users themselves are equipped to make their own decisions on which approach is to be acted upon.

Such debate and critique is an important feature, because it relies on a commitment to supporting what works best in any given environment or sector. Thus, the online collaborative environment becomes one in which new or existing knowledge is tested and evolves through time, learning as much by what fails as by what succeeds.

Recommendations to support the practice and deployment of public KM

In this final section, we now focus on our key recommendations arising from this case study of a KM intervention described in this paper. Our objective now is to provide suggestions about how the socio-technical aspects of Australia's primary industries R, D and E framework could be further developed to enable public KM and through this create the conditions for the emergence of a more effective innovation system for agriculture.

Enable the emergence of collaborative LNs via a focus on personal KM

Since its launch, eXtension has developed and deployed technology to streamline the incorporation of end user needs into the processes of developing and deploying innovations. It has been doing this by developing a series of interacting support-system modules that allow for effective engagement between CoIs and CoPs. The core modules include provision for a public facing website (Extension.org); a registration system for people (people.extension.org); a collaborative publishing system/workspace (create.extension.org); a system to ask questions (ask.extension.org), a custom search engine (search.extension.org); and a system to support distributed learning (learn.extension.org). Some of the reported critical success factors identified are the capacity by which eXtension has provided access to system-wide expertise to respond to client needs; that gaps in institutional capability have been filled through cross-institutional and cross-jurisdictional collaborations; that substantially more grant funding has been leveraged though the communities; that professional development opportunities are enhanced; that communities are able to use social media in new ways to extend the reach and engagement and; that the use of extension.org extension website extends the reach, discoverability and engagement of extension organisations (eXtension, 2013b).

We conclude here therefore that the learnings derived from the US eXtension experience provides a robust foundation to pilot the establishment of a range of LNs and we would encourage that in an Australian context, the specific inclusion of private sector service providers explicitly be included in any on-going initiative.

Engage multiple institutions in adopting standards-based content management

In the United States, as LNs have evolved from the collaborations between members of CoIs and CoPs, it has been found there is often a shift away from creating content as knowledge artefacts towards becoming curators of content from across multiple institutional repositories. This represents the idea that members of LNs, become curators of distributed content (Cotton, 2012). The intention of eXtension then is not necessarily to hold or manage these publications.

This sort of approach to KM does represent additional challenges beyond current KM policy directions in Australia. For example, the PISC KM Working Group (2012) published a set of KM guidelines in August 2012 in which it states that 'Each research organisation will need to have its own repository and contribute its records to the National Library of Australia's Trove[2] harvester and aggregator search engine' (*ibid*, p 5). 'Agencies should store their publicly available research outputs and associated metadata in their own digital repositories in a format and manner that makes them available to aggregator and harvester systems. The OAI-PMH is the internationally recognised approach for achieving this compliance' (*ibid*, p 6). The guidelines go on to state that 'Compliance with OAI-PMH Exchange Protocol requires use of Dublin Core (DC) metadata vocabulary.' (*ibid*, p 13). However, it is the case that the common element across systems will be the people, organisations, projects and other conceptual (or context) entities that both produce resources, but also are key components of LNs themselves. We conclude from this that any decision to adopt an eXtension type business model in Australia would require a shift beyond a primary focus on resource metadata towards a conceptual model based on context entities. The 2001 'Toronto Tenets: Principles and Criteria for a Model for Archival Context Information' provides details of this requirement (Pitti, 2001). 'Context information is not metadata that describes other information resources, but information that describes entities that are part of the environment in which information resources (i.e., records) have existed'.

Create a registry system to share expertise and encourage innovation

Our contention is that the eXtension initiative in the United States has gone some of the way to establishing the foundation for the public use of context entities. This idea is embryonic within its 'people module'. For all eXtension modules other than the extension.org website, full functionality is only accessible with an eXtension ID. Once an eXtension ID has been confirmed, the user can set up a profile, including information such as their contact details, institutional affiliation, areas of interest and social

[2]Eight years in the making, Trove is a search engine developed by the National Library that aggregates the information from 1000 libraries, art galleries, archives, research repositories and museums in Australia (Vyver, 2010).

media identities. During his visit, Wood (2013) indicated there are plans to develop the capability of this module to support interoperability with other eXtension modules. Additional functionality could thus be incorporated as part of the development of a primary industries R, D and E authority register to facilitate the sharing of expertise across jurisdictions and to support innovation. The Encoded Archival Context – Corporate Bodies, Persons and Families (EAC-CPF) is an existing international standard for developing a register of context entities (Staatsbibliothek zu Berlin and the Society of American Archivists, 2009) and it was specifically created to 'provide a communication standard for the exchange of authority records based on International Standard for Archival Authority Records—Corporate Bodies, Persons, Families '. This standard is fully compliant with OAI-PMH repositories and the harvesting of content from these. The National Library of Australia already actively uses and supports this standard to harvest information (including about resources) from distributed knowledge resources for discovery and display.

Expand the scope of 'shared context' to include open access policies

The use of an authority register for context entities as a foundation for public KM has the potential to expand the scope of 'shared context' into the societal domain of the knowledge hierarchy and the fourth dimension of the records continuum. It is by locating these context entities in dimension 4 of the records continuum that it becomes possible to interconnect separate information systems in an open contextual information framework (McCarthy and Upshall, 2006). Public KM becomes a task that involves the management of the boundary dynamics that emerge between a public and a personal knowledge space, as well as the support for interoperability between digital repositories of the institutions involved in the realm of personal KM as previously described. By locating context entities such as people, organisations, and R, D and E concepts like sector and cross-sector strategies, programmes and projects in dimension 4 of the records continuum there is potential to create linkages with a wider range of stakeholders including users, research, policy, practice change personnel and private sector service providers. It is likely that this trend towards a more formal approach to integrating records management within the context of on-line repositories as outlined in the records continuum model are likely to accelerate. For example, a recent announcement by the Victorian Government indicates going forward that all government data and information will be made accessible by the general public (Department of Treasury and Finance 2012). This trend is extending into the agricultural domain with the launch by USDA (2013) Agriculture Secretary Tom Vilsack of a virtual community to give increased public access to food, agriculture and rural data. The Obama administration has now entered this policy realm with the recent Presidential Executive Order declaring that 'information is a valuable national asset whose value is multiplied when it is made easily accessible to the public' (White House, 2013).

Overall, we conclude that analysis of the DPI Visiting Fellow's programme outlined in this paper has cast light on what we have described as the practice of public KM. We have argued this involves combining the principles and practices underpinning open information access, contextual information management and collaborative LNs. Through this, we see there is potential to strengthen the capacity of Australia's primary industries R, D and E system as a national innovation system and thus create and deploy solutions to problems more efficiently and effectively.

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